Task 4: Develop New Practical Color Vision Tests for ATCS Applicants (Chidester)

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University/Contract Performing Organization:
Contractor TBD for (1) validation data collection and reporting for ATCOV 5.0, and (2) depiction of CAD score prediction of perceptible CIE color space

Project Start Date: October 2007 **Anticipated End Date:** December 2010

Requirements Statement

Operational Shortfall or Knowledge Gap
The Air Traffic Organization (ATO) and Office of Aerospace Medicine (OAM) require research support to revise the Air Traffic Color Vision Test (ATCOV) to ensure compliance with the *Uniform Guidelines on Employee Selection Procedures (1978)* and correct practical problems encountered during implementation, correlate its findings with new high-precision tests of color vision perception, and continue assessment of perception of deployed display colors to determine whether improved testing and future display color standards could be provided by higher precision color perception measurement.

Benefit in Closing the Shortfall or Gap
Implementing a revised version of ATCOV will ensure that newly selected controllers have adequate color vision to safely operate current ATC technologies and that the test fully complies with the *Uniform Guidelines*. Collecting CAD data will enable future decisions concerning color vision qualification standards and may allow specification of an allowable color envelope for future displays. This may allow the replacement of an ATO-unique occupationally-validated test (ATCOV) with an occupationally-validated clinical test (CAD), or allow recalibration of the ATCOV to ensure that it precisely samples the deployed display color space. The former would be infinitely preferable to the latter. In the absence of documentation of perceptual ability clearly linked to job performance, color vision professionals have, and FAA personnel must continue, to recalibrate the colors used in the occupationally-validated test each time color usage in job duties changes.

Description of the Desired Product
1) Development and deployment of the revision to ATCOV to selected FAA offices. This will require development of the revision and testing of a small cadre of normal and color

deficient subjects to ensure cutoff scores are appropriate.

2) Measurement of chromaticity of colors deployed for critical functions in Air Traffic displays and mapping to the color space measured by the CAD.

3) Analysis of CAD test data quantifying color deficient candidates' ranges of color perception ability, to assess whether the CAD reliably predicts ATCOV success and documents a consistent CIE color space which could be used for future selection decisions and criteria for future air traffic displays.

4) Technical reports / research papers that document any gaps between ATCOV testing and the display color map, recommend any revisions to color vision testing, and recommend specifications for a standard color envelope for future Air Traffic displays.

Schedule
December 2010

Research Objective
Update occupational color vision testing for ATCS candidates and assess whether improved testing and future display color standards could be provided by advanced clinical color vision tests.

Background
The FAA developed and deployed practical color vision tests (Flight Progress Strip Test and Aviation Lights Test) in 1992 for medical qualification of Air Traffic Control Specialist (ATCS) candidates. These tests were not adequate to test candidates' ability to discriminate the range of colors used for critical functions in current ATC displays. As a result, color vision deficient (CVD) ATCS candidates identified by the Dvorine Color Vision Test were temporarily assigned a pending status, awaiting a new occupationally-validated test to allow clearance of candidates with any type of color vision deficiency possessing adequate color perception to discriminate colors deployed in critical ATCS job duties. CAMI personnel developed and validated a research version (Xing) and deployed an operational version (Chidester & Milburn) of ATCOV. The Operational ATCOV is a true job sample test, making use of display formats and color values deployed for critical functions on critical displays as defined by published task analyses of ATCS duties. Its items are isomorphic with datablocks, datalines, and weather depictions deployed on ARTS, STARS, DSR, and URET displays deployed to Terminal and En route facilities. It assesses whether a candidate can discriminate the colors deployed for critical tasks in current Air Traffic displays. AGC determined that implementing the ATCOV was appropriate, pending documentation of compliance of validation studies with the *Uniform Guidelines* during FY09. That documentation, completed in November 2009, recommended a number of minor but important changes to ensure compliance and provided justification for shortening the test by removing two subtests, which was supported by the validation data. A revised version of the ATCOV is required, deleting the URET subtest (because all colors used are redundantly coded and, therefore, it is more appropriate to provide training on the use of redundant coding than to reject those who cannot discriminate the colors) and Multitasking subtest (because its results

were extremely highly correlated with the Radar Identification subtest). It will also correct practical problems encountered during operational deployment (tendency of candidates in a jeopardy situation to over practice and to repeatedly review instruction and sample screens) which were not encountered in the validation study.

As ATCOV was developed, parallel advances in clinical color vision testing have resulted in a test (CAD) that precisely documents the range of color perception ability of normal and color vision deficient individuals. In contrast to a job-sampled and validated test, this approach attempts to more precisely measure the capabilities of a person and map color perception to a standard (International Commission on Illumination; CIE 1931) color space. CAD scores precisely quantify an applicant's range of color perception ability. The colors deployed for critical functions in Air Traffic displays can be mapped to the same color space, potentially allowing specification of necessary color perception on a precise clinical test and specification of an allowable color envelope for future displays for which the ATCS population is certified to perceive and discriminate.

AAM currently assesses and clears candidates for color vision deficiency as follows:

- All candidates undergo initial screening using the Dvorine Color Vision Test. Candidates who pass have normal color vision perception.
- Candidates who fail the Dvorine have some degree of color vision deficiency. They complete the ATCOV to determine whether they can be medically cleared, and are asked to take the Colour Assessment and Diagnosis (CAD) test as a research instrument. Candidates who pass ATCOV are medically-cleared as having adequate ability to perceive colors used in current critical Air Traffic displays. CAD test scores are collected from this group for research documenting perceptual abilities required to pass the ATCOV and, in turn, testing this range of abilities necessary to the color space deployed in Air Traffic displays.
- Candidates who fail the ATCOV are medically disqualified. CAD scores are collected from this group for research to improve testing and display standards.

Previous Activity on this Task
CAMI personnel (Xing) previously developed and validated a research version of ATCOV. In FY09, CAMI (Chidester and Milburn) and AAM-200 personnel (Lomangino) specified, developed (AAM-500 contractor), validated, and implemented an operational version of the ATCOV (version 4.3), contracted for and received an *Uniform Guidelines* evaluation of ATCOV, and acquired and deployed the CAD test to those Regional Flight Surgeon's offices who conduct medical evaluations of ATCS candidates.

Proposed or Planned Research
Research is required to:
- Develop and deploy a revision to the Operational ATCOV to appropriate Regional Flight Surgeon's offices
- Measure chromaticity of colors deployed for critical functions on ATC displays and map them to the CIE color space, for which candidate color perception is measured by the CAD

- Analyze CAD test data quantifying color deficient candidates' range of color perception ability, to assess whether the CAD reliably predicts ATCOV success and documents a consistent CIE color space which could be used for future selection decisions and criteria for future air traffic displays.
- Complete technical reports / research papers that document any gaps between ATCOV testing and the CIE color space used for critical functions on ATC displays, recommend any revisions to color vision testing, and recommend specifications for a standard color envelope for future Air Traffic displays

Research Question(s)
What is the CIE color space perceptible by those who can discriminate currently deployed colors used in critical Air Traffic functions?

What area of the CIE color space would include current and near-term display colors used to accomplish critical Air Traffic functions?

Can more effective color vision testing be accomplished through a high-precision clinical test mapped to a critical color space than may be accomplished through a job-sample test?

Can standards for future Air Traffic displays be specified from the documented perception capabilities of the ATCS population?

Technical Approach

Current Year
ATCOV revision, measurement of chromaticity of colors deployed for critical functions in Air Traffic displays, mapping these values to the CIE color space, CAD data analysis relative to ATCOV decisions and deployed color space.

Out Years
Technical reports documenting any gaps between ATCOV testing and the display color map, recommending any revisions to color vision testing, and recommending specifications for a standard color envelope for future Air Traffic displays are to be completed during the first quarter of FY11.

Air Traffic Resources Required
Access to ATC subject matter experts for advice concerning deployed systems. This may require contacts with instructional personnel from the Academy in Oklahoma City or with research psychologist colleagues at the Technical Center. Though current plans will complete all measurements using equipment currently available at CAMI, we may need to take measurements at the Academy or an en route facility to incorporate critical colors in ERAM if they use RGB values significantly different from the values used in DSR.

IT Resources Required

- Support for Colour Assessment and Diagnosis (CAD) test units deployed to Regional Flight Surgeon facilities, including calibration oversight.
- Support for Xyant development of ATCOV 5.0, including advising scoring program development and creation of installation materials for distribution.
- Creation of method for displaying color samples on Sony 2K monitors. Creation of method for displaying color samples on ERAM monitors, if required.
- Support for contractor (TBD) use of ATCOV 5.0 interim and/or final versions for cut score validation.

Calibration
Systems on which ATCOV and CAD testing are conducted require calibration via procedures included in their operating manuals. Colorimeters used in measuring deployed colors require calibration via procedures included in their operating manuals.

FY10 Milestone Schedule		
Description	Proposed Start Date	Proposed Completion Date
Specify ATCOV version 5.0 incorporating all changes recommended in *Uniform Guidelines* evaluation and correcting practical problems encountered during implementation	November 2009	December 2009
Revise and implement ATCOV scoring program to provide interim accommodations to *Uniform Guidelines* evaluation	December 2009	January 2010
Complete measurement and mapping of colors deployed for critical functions on ATC displays to CIE color space to document envelope of critical colors in all current displays	December 2009	February 2010

Advise development and accept ATCOV 5.0 testing prototype from contractor	December 2009	June 2010
Complete data collection among normal and color vision deficient subjects to verify cut scores	June 2010	August 2010
Complete measurement and mapping of colors planned for critical functions in ERAM to the CIE color space to determine whether ERAM will modify the critical color envelope	July 2010	August 2010
Advise development and accept ATCOV 5.0 final version from contractor	August 2010	September 2010
Implement ATCOV version 5.0 at Regional Flight Surgeon offices	September 2010	October 2010
Report to AAM-1 color envelope perceptible by those who pass and fail ATCOV	September 2010	October 2010
Report to AAM-1 any recommendations for revision of color vision testing procedures	October 2010	December 2010
Report to ATO any recommendations for a standard envelope for future displays	October 2010	December 2010
Complete OAM Technical Report documenting deployment of ATCOV, subsequent research on color displays, and recommendations for testing and display specifications	October 2010	December 2010

FY10 Deliverables		
Description	Proposed completion date	Actual completion date
ATCOV version 4.3 scoring program revision	January 2010	January 2010
ATCOV version 5.0	September 2010	
Report to AAM-1 color envelope perceptible by those who pass and fail ATCOV	September 2010	
Report to AAM-1 any recommendations for revision of color vision testing procedures	December 2010	
Report to ATO any recommendations for a standard envelope for future displays	December 2010	
Complete OAM Technical Report documenting deployment of ATCOV, subsequent research on color displays, and recommendations for testing and display specifications	December 2010	
Supporting materials will be provided at the request of the AJP-61 Program Management. These include power point charts and briefing slides for TCRG meetings, abstracts for reports that don't already include them, quarterly reports, and text for the annual report summarizing the year's activities.	As needed	